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PATENT & TRADEMARK OFFICE

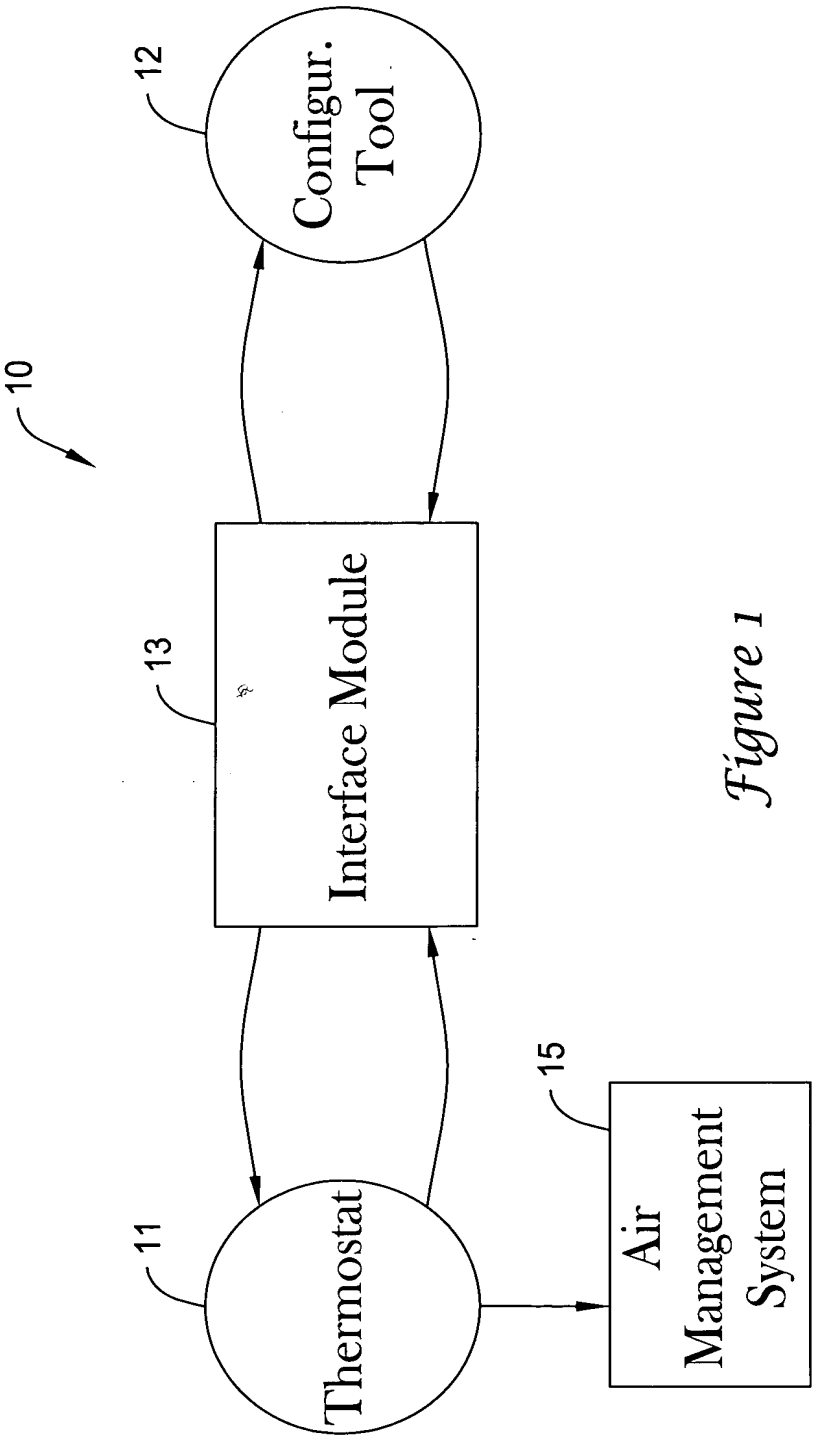
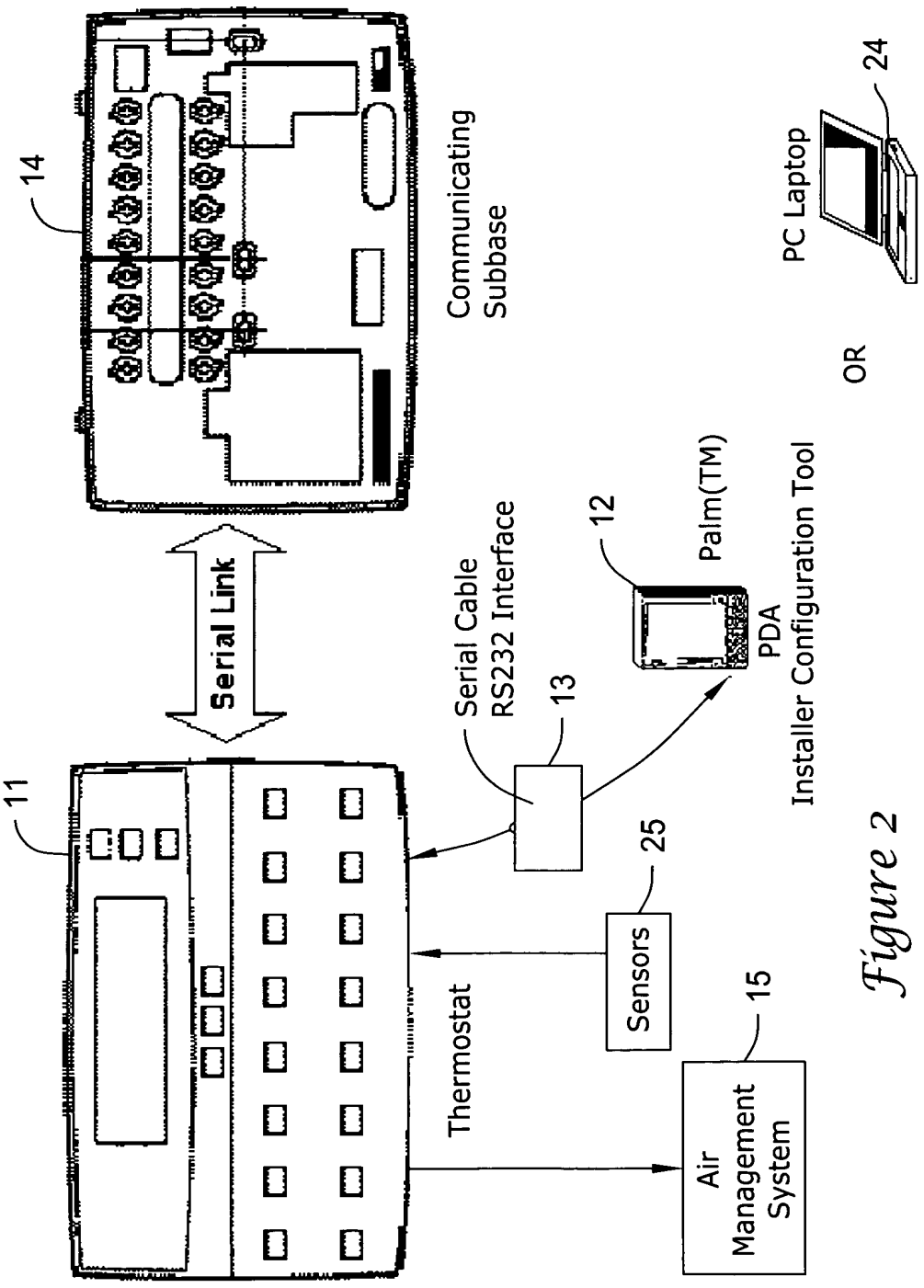


Figure 1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Communicating Subbase
PC Laptop
24
OR
Serial Link
Serial Cable RS232 Interface
12
Palm(TM) PDA
Installer Configuration Tool
11
13
25
Sensors
Thermostat
15
Air Management System

Figure 2

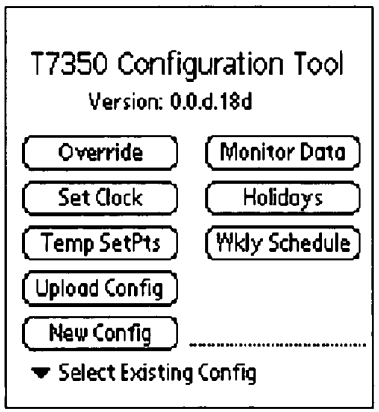
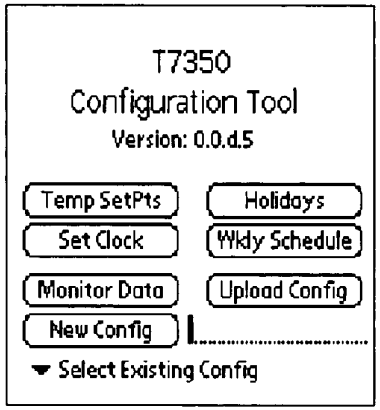


Figure 3A



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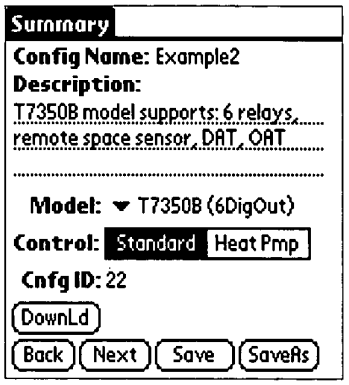

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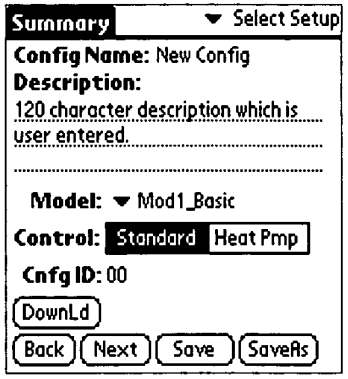

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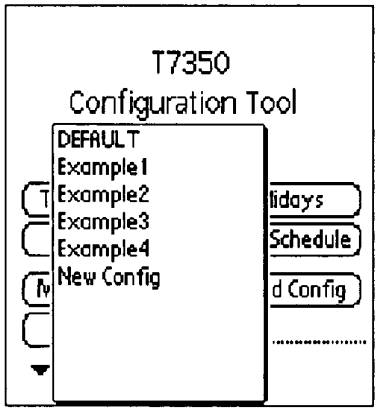

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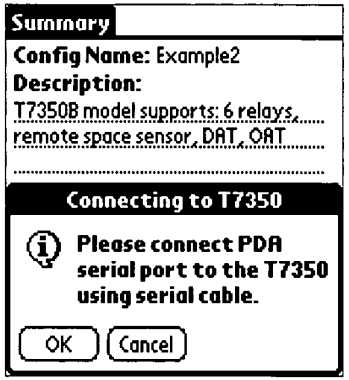

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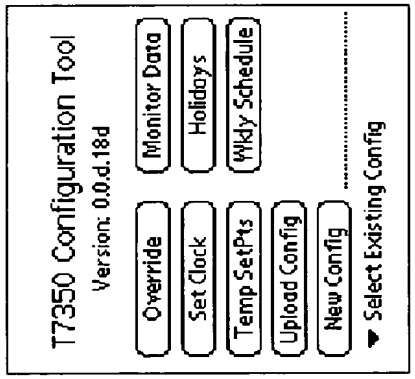

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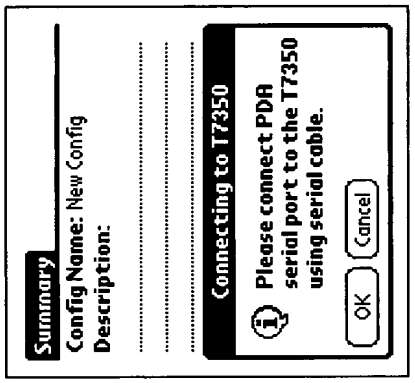

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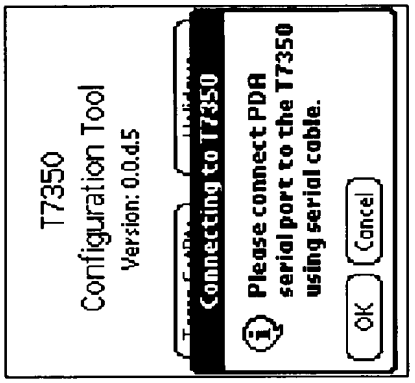

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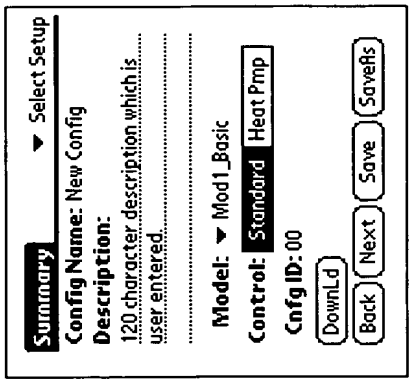

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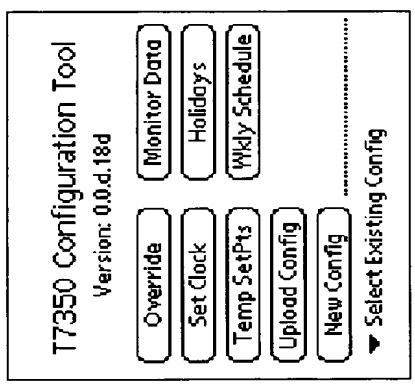


Figure 6C

Figure 6B

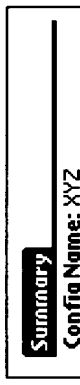


Figure 6D

Figure 7A

Figure 7B

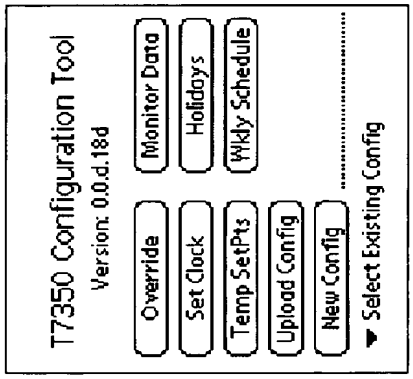
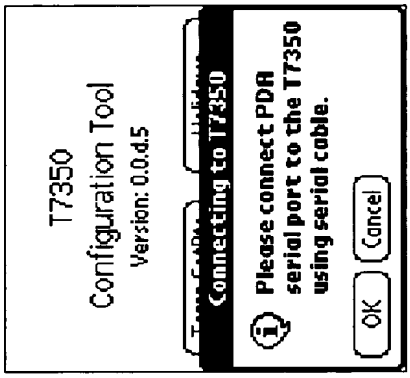


Figure 8A



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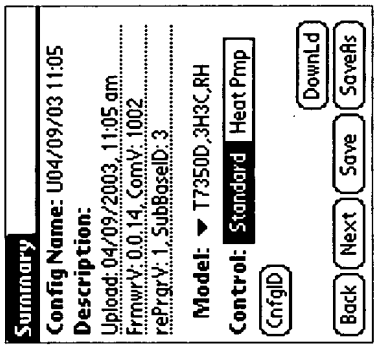

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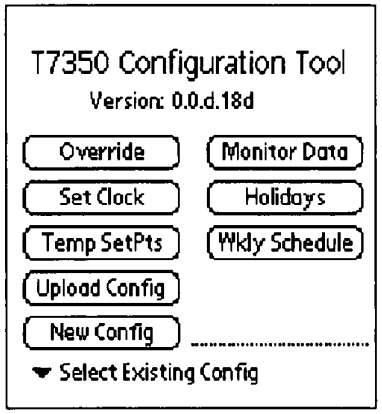

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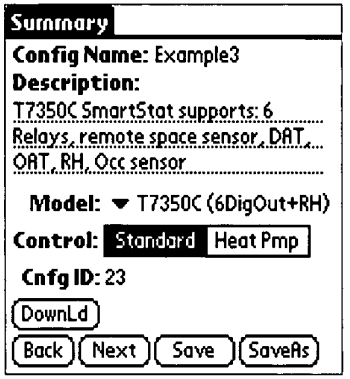
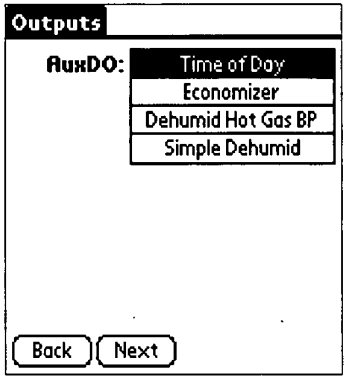


Figure 9A



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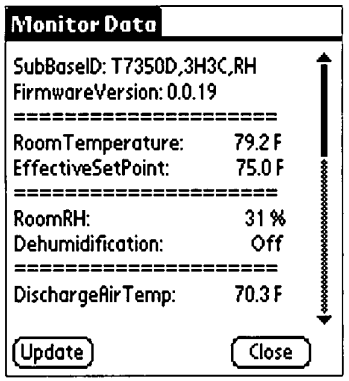
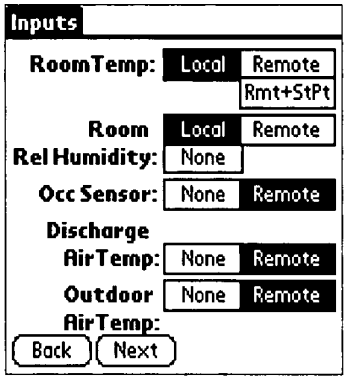


Figure 8E



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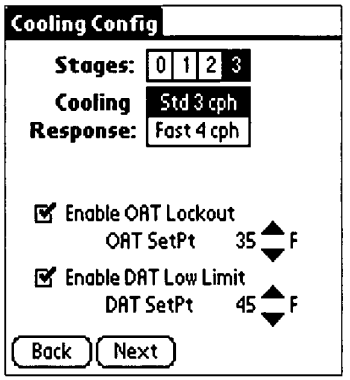

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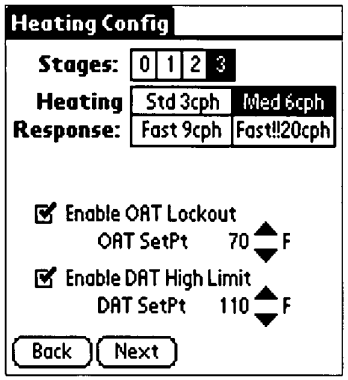

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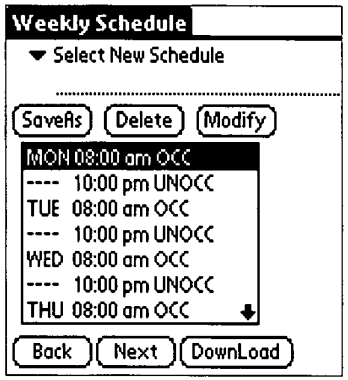

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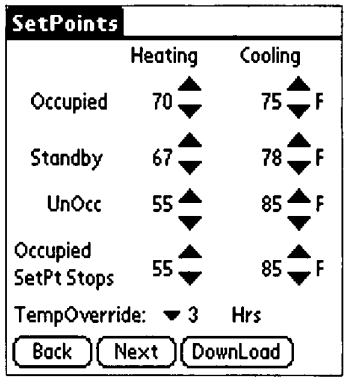
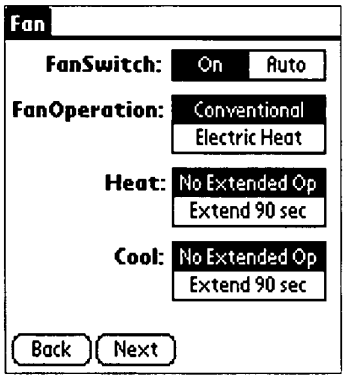


Figure 9I



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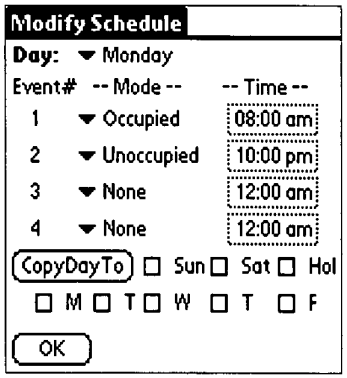


Figure 9H

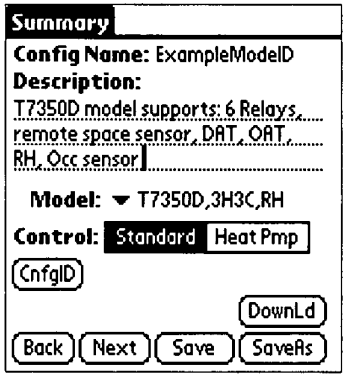


Figure 9J

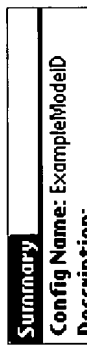
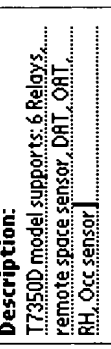


Figure 10A



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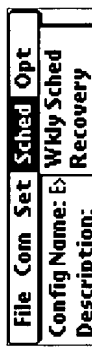

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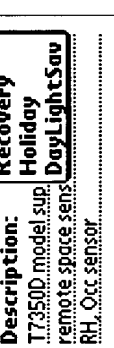


Figure 10D

Figure 10E

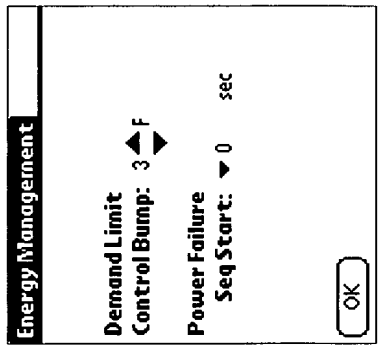


Figure 10F

Figure 10G

Figure 10I

Figure 10K

Figure 10H

Figure 10J

Figure 10L

Figure 11A

Figure 11B

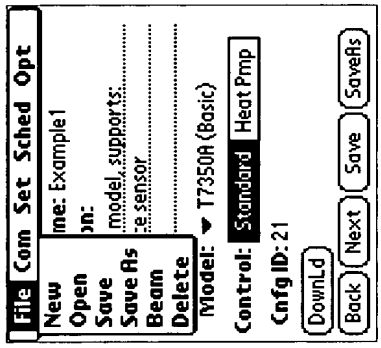
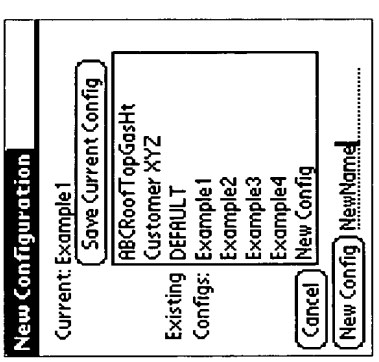


Figure 12A



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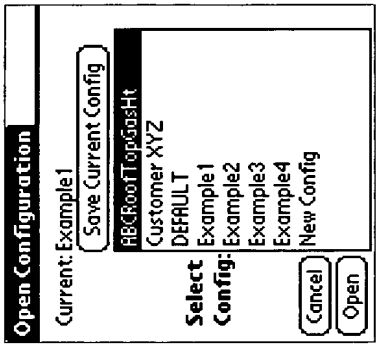

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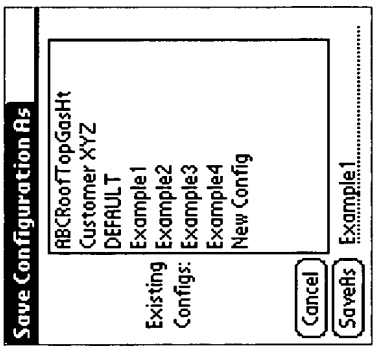

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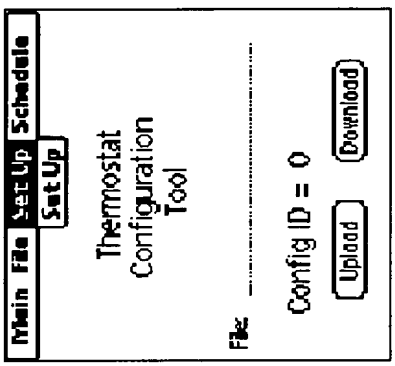

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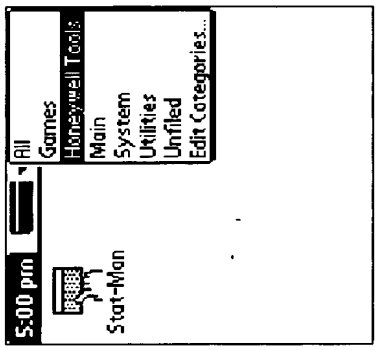

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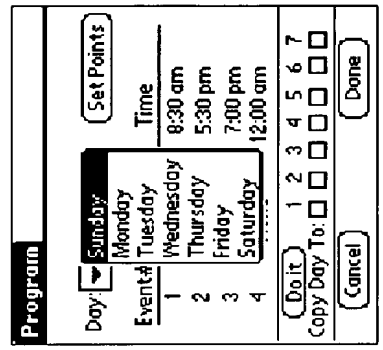

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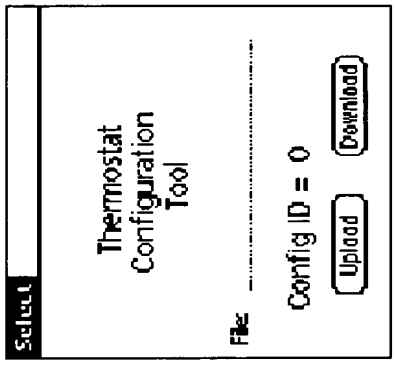

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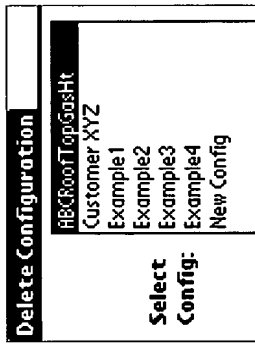
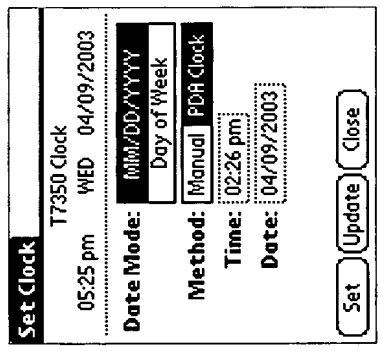


Figure 12E



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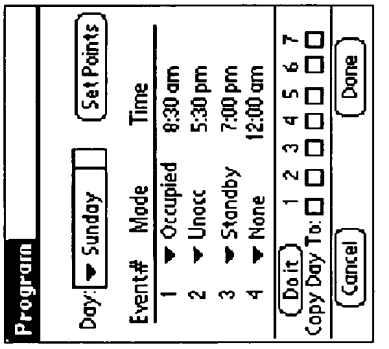

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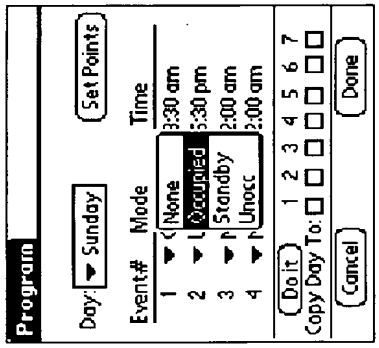

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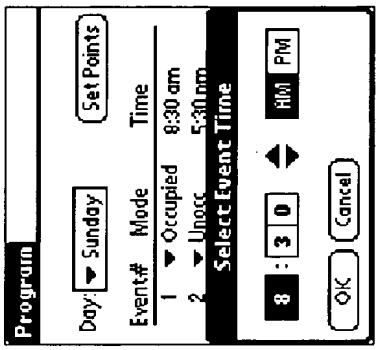
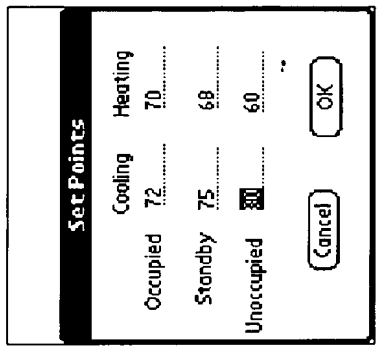


Figure 14G



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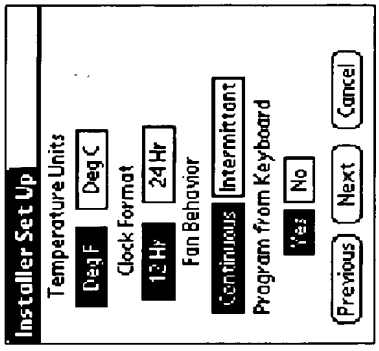


Figure 14I

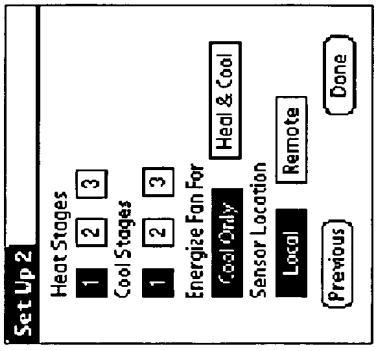
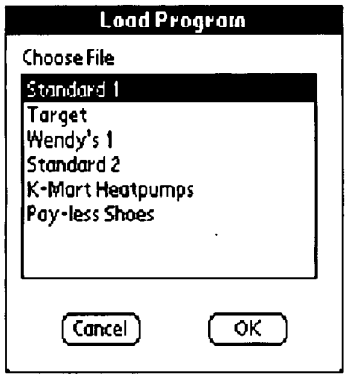


Figure 14J



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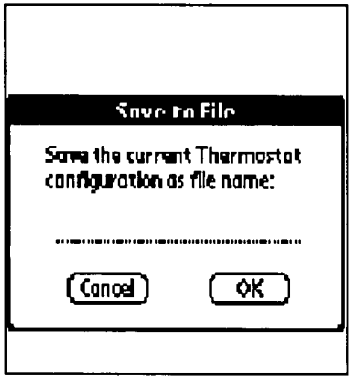

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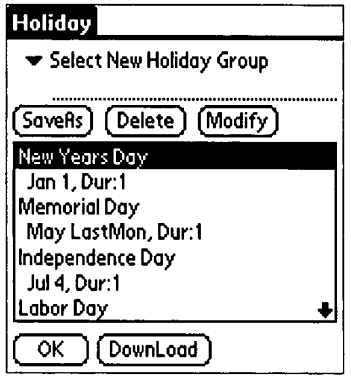

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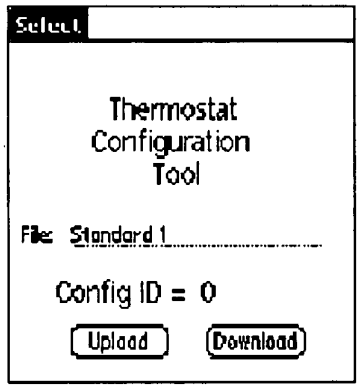

Figure 14L

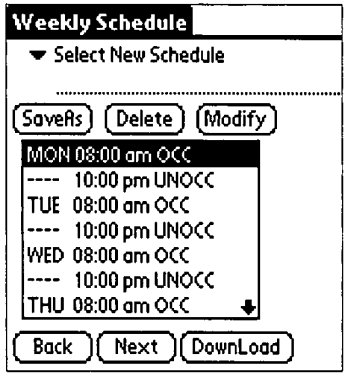

Figure 14N

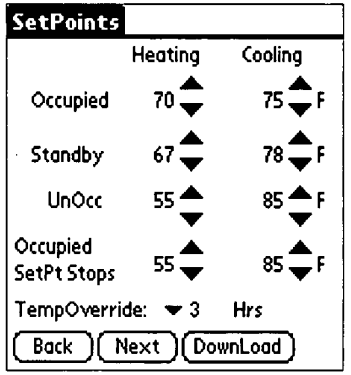

Figure 14P

Figure 14Q

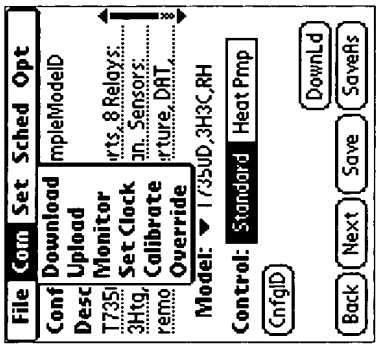

Figure 14S

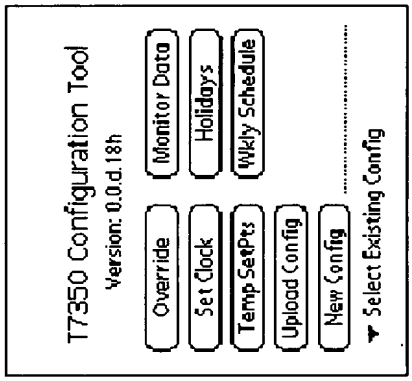

Figure 14T

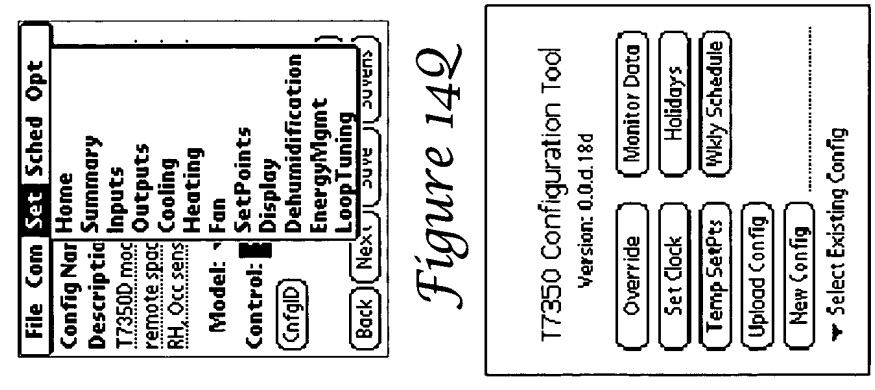

Figure 14R

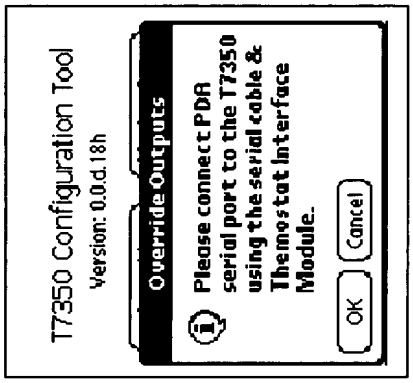

Figure 14U

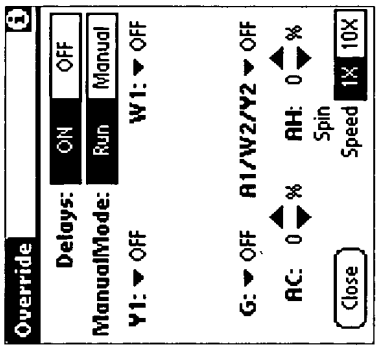

Figure 14V

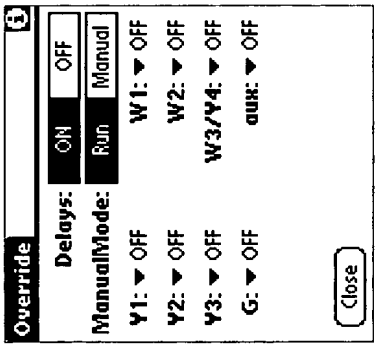

Figure 14W

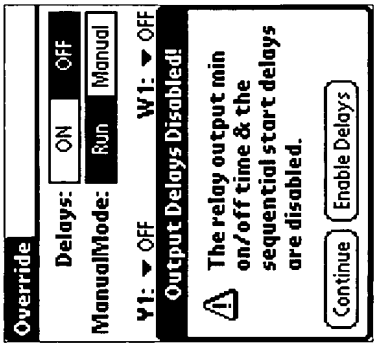

Figure 14Y

Figure 14Z

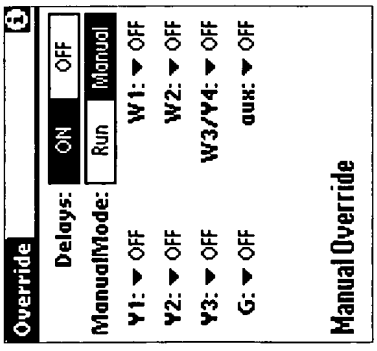

Figure 14X

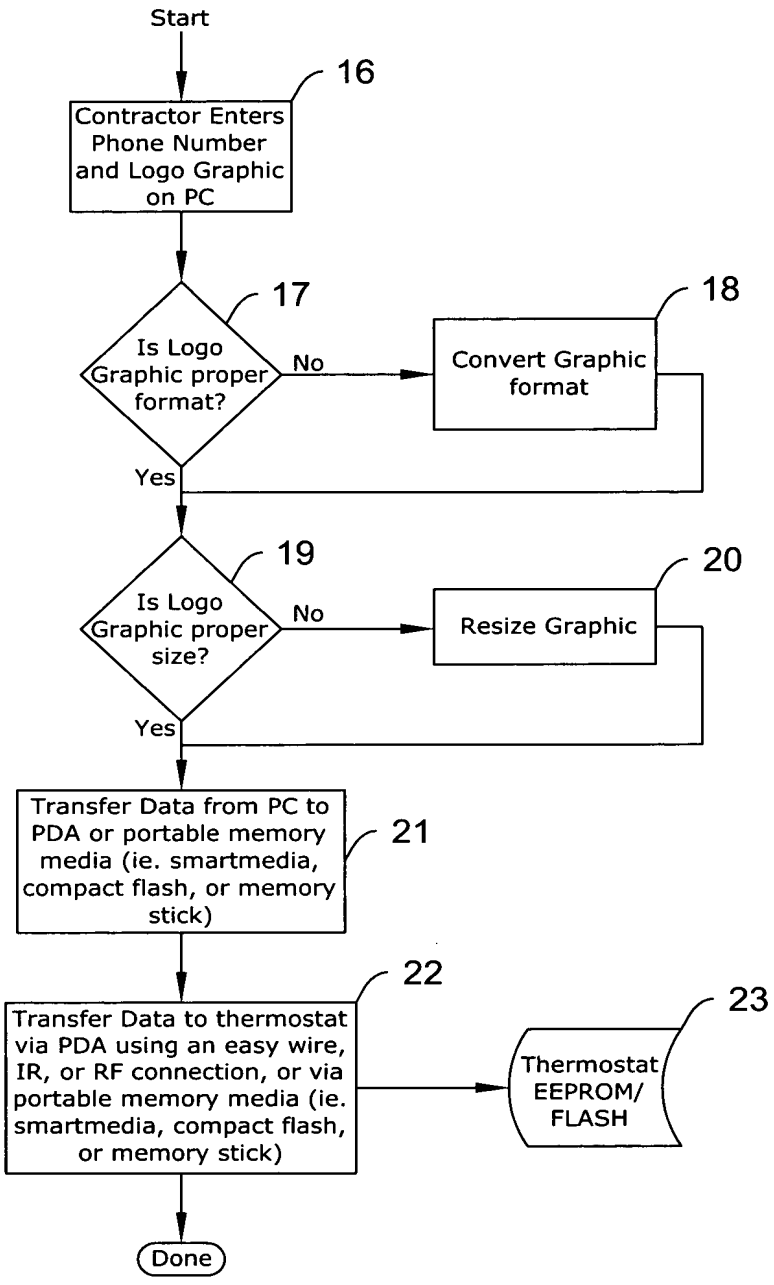
Start
16
Contractor Enters Phone Number and Logo Graphic on PC
17
Is Logo Graphic proper format?
No
18
Convert Graphic format
Yes
19
Is Logo Graphic proper size?
No
20
Resize Graphic
Yes
Transfer Data from PC to PDA or portable memory media (ie. smartmedia, compact flash, or memory stick)
21
22
Transfer Data to thermostat via PDA using an easy wire, IR, or RF connection, or via portable memory media (ie. smartmedia, compact flash, or memory stick)
23
Thermostat EEPROM/ FLASH
Done

Figure 15

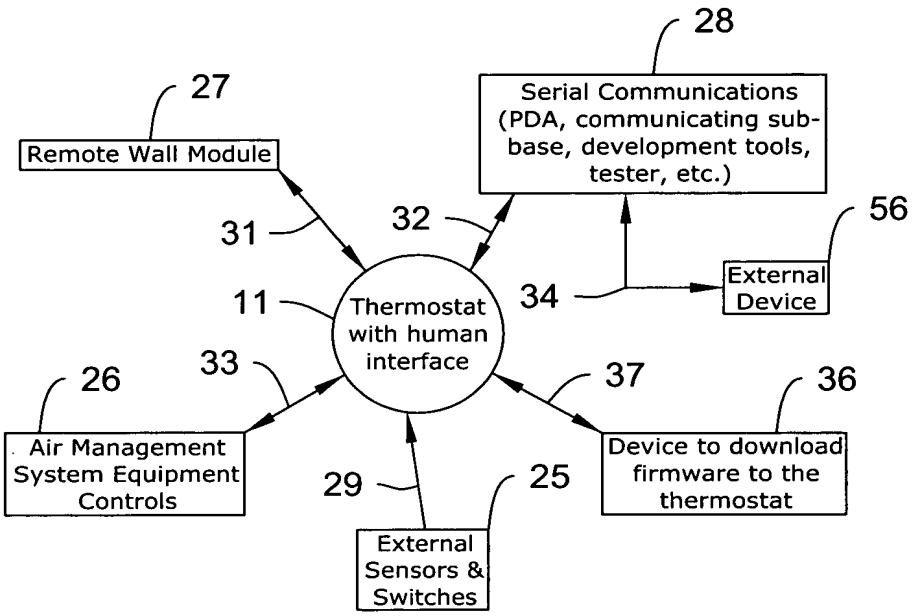
28
Serial Communications (PDA, communicating sub-base, development tools, tester, etc.)
27
Remote Wall Module
31
32
56
External Device
34
11
Thermostat with human interface
33
26
37
36
Air Management System Equipment Controls
Device to download firmware to the thermostat
29
25
External Sensors & Switches

Figure 16

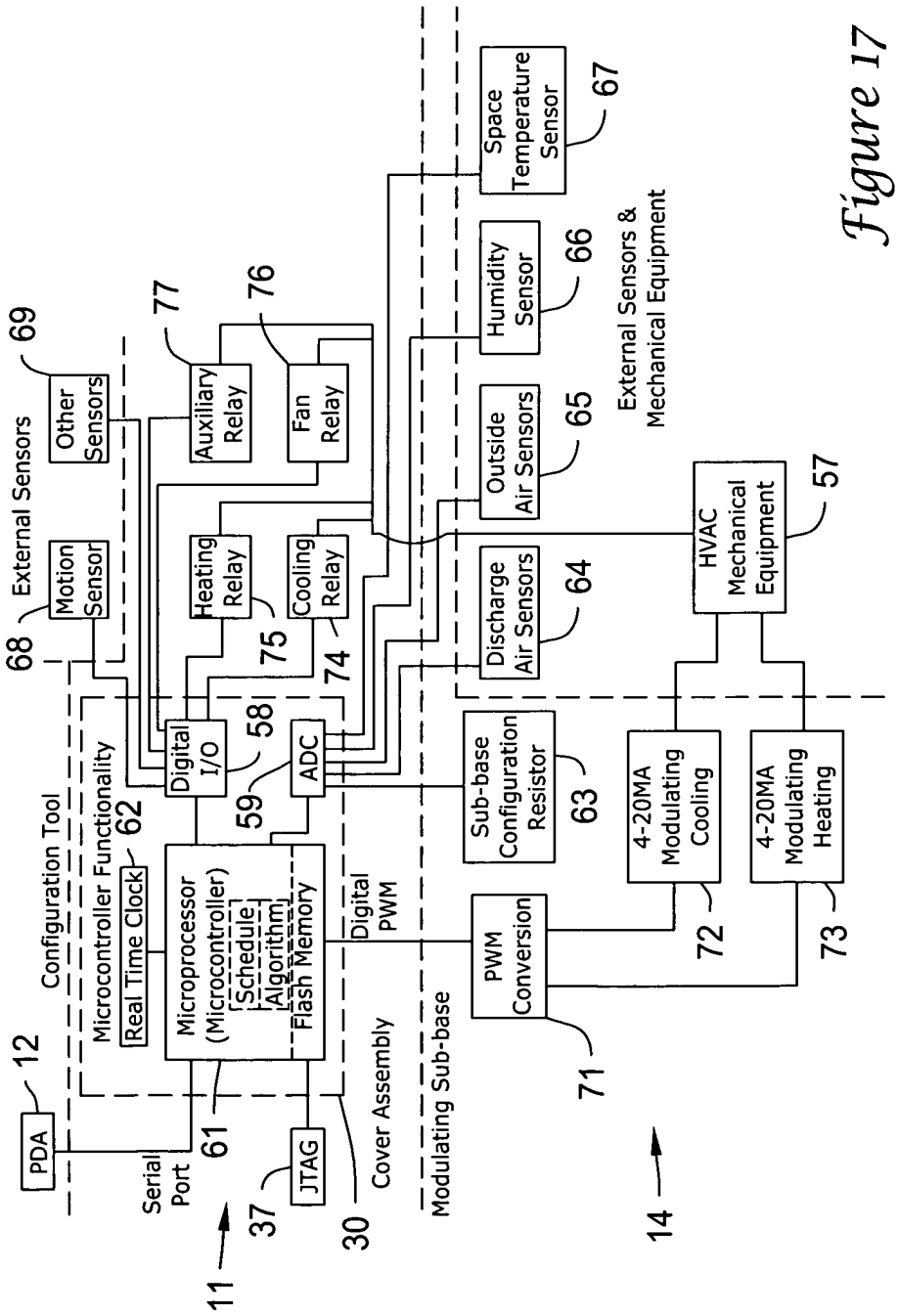
External Sensors
Configuration Tool
Microcontroller Functionality
Modulating Sub-base
Cover Assembly
Serial Port
PDA
JTAG
Real Time Clock
Microprocessor (Microcontroller)
Schedule
Algorithm
Flash Memory
Digital I/O
ADC
Digital PWM
PWM Conversion
Sub-base Configuration Resistor
Other Sensors
Motion Sensor
Auxiliary Relay
Heating Relay
Cooling Relay
Fan Relay
Discharge Air Sensors
Outside Air Sensors
Humidity Sensor
Space Temperature Sensor
External Sensors & Mechanical Equipment
HVAC Mechanical Equipment
4-20MA Modulating Cooling
4-20MA Modulating Heating
11
12
14
30
37
57
58
59
61
62
63
64
65
66
67
68
69
71
72
73
74
75
76
77

Figure 17

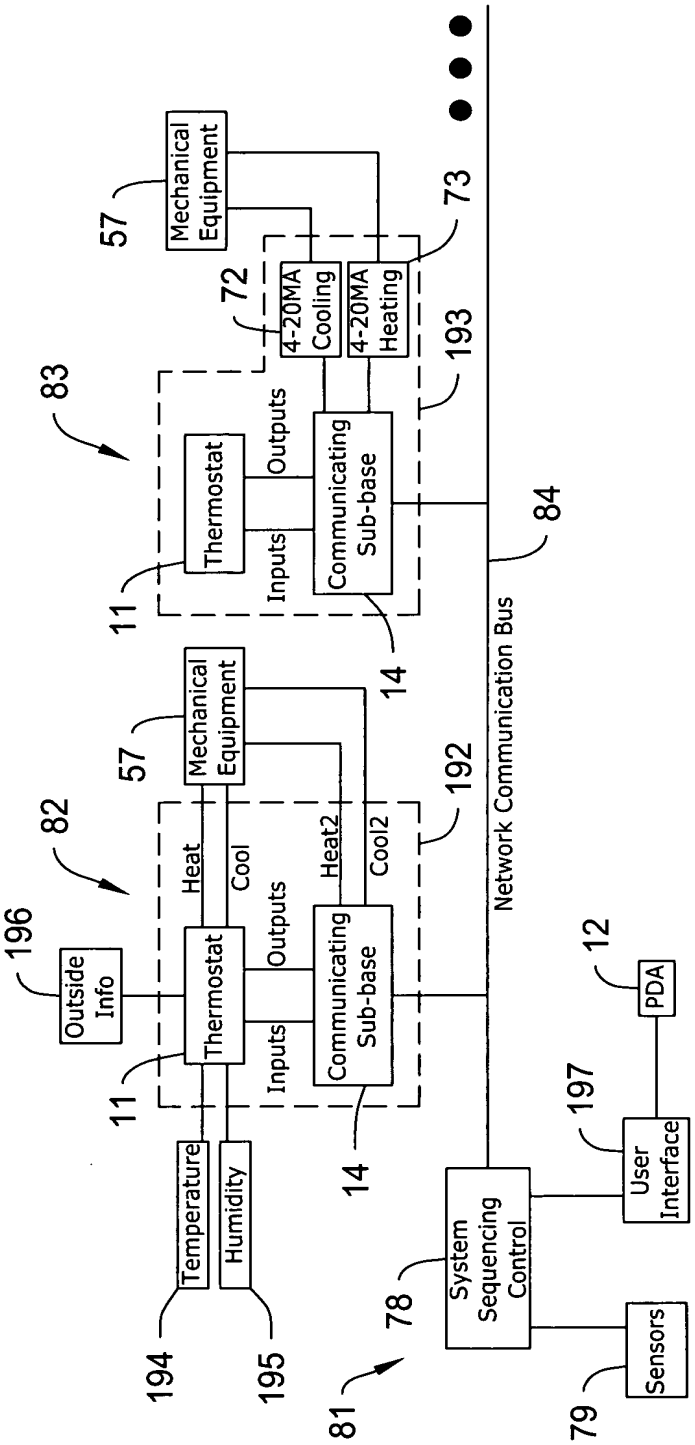
Mechanical Equipment
57
73
72
4-20MA Cooling
4-20MA Heating
193
83
Thermostat
Outputs
Inputs
Communicating Sub-base
11
14
84
Network Communication Bus
Mechanical Equipment
57
192
82
Heat
Cool
Heat2
Cool2
196
Outside Info
Thermostat
Outputs
Inputs
Communicating Sub-base
11
14
12
PDA
197
User Interface
Temperature
Humidity
194
195
78
System Sequencing Control
81
79
Sensors

Figure 18

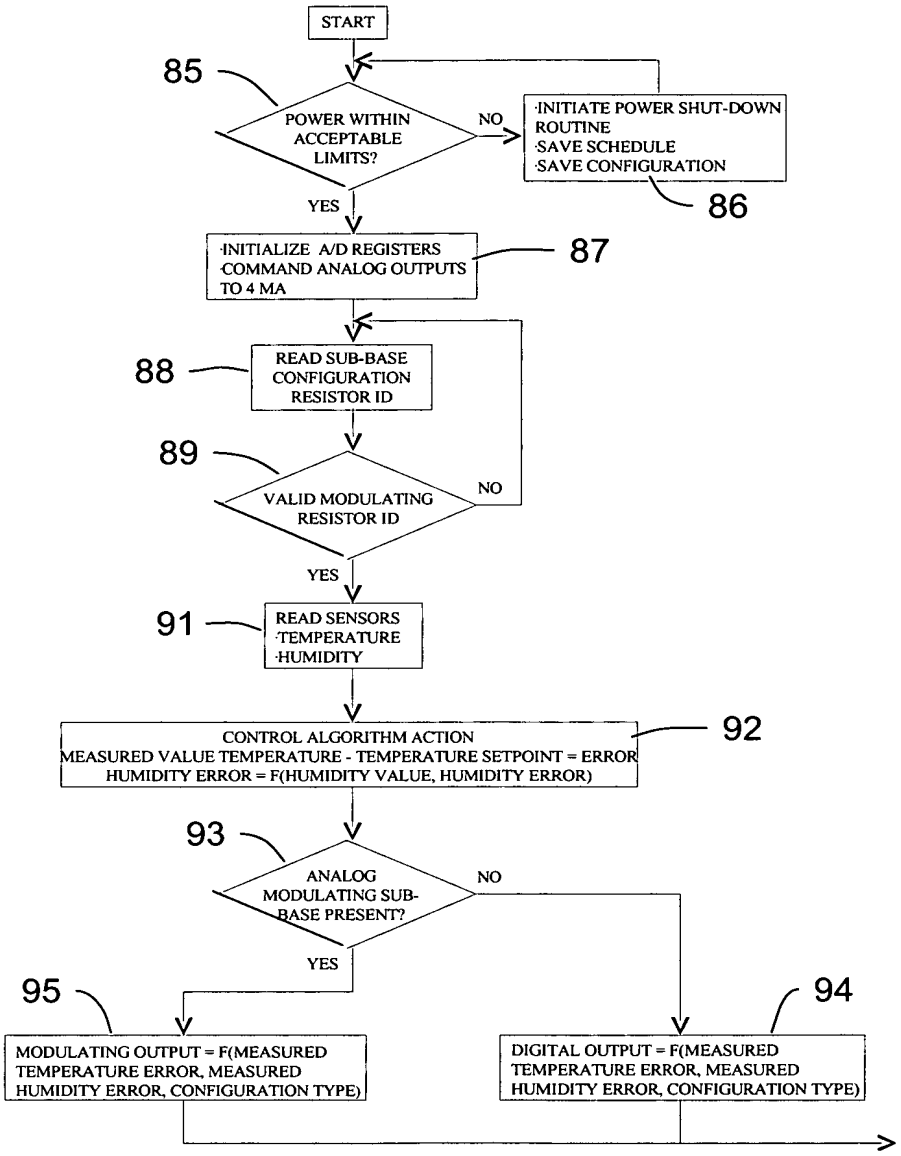
START
85
POWER WITHIN ACCEPTABLE LIMITS?
NO
·INITIATE POWER SHUT-DOWN ROUTINE
·SAVE SCHEDULE
·SAVE CONFIGURATION
86
YES
·INITIALIZE A/D REGISTERS
·COMMAND ANALOG OUTPUTS TO 4 MA
87
88
READ SUB-BASE CONFIGURATION RESISTOR ID
89
VALID MODULATING RESISTOR ID
NO
YES
91
READ SENSORS
·TEMPERATURE
·HUMIDITY
CONTROL ALGORITHM ACTION
MEASURED VALUE TEMPERATURE - TEMPERATURE SETPOINT = ERROR
HUMIDITY ERROR = F(HUMIDITY VALUE, HUMIDITY ERROR)
92
93
ANALOG MODULATING SUB-BASE PRESENT?
NO
YES
95
94
MODULATING OUTPUT = F(MEASURED TEMPERATURE ERROR, MEASURED HUMIDITY ERROR, CONFIGURATION TYPE)
DIGITAL OUTPUT = F(MEASURED TEMPERATURE ERROR, MEASURED HUMIDITY ERROR, CONFIGURATION TYPE)

Figure 19

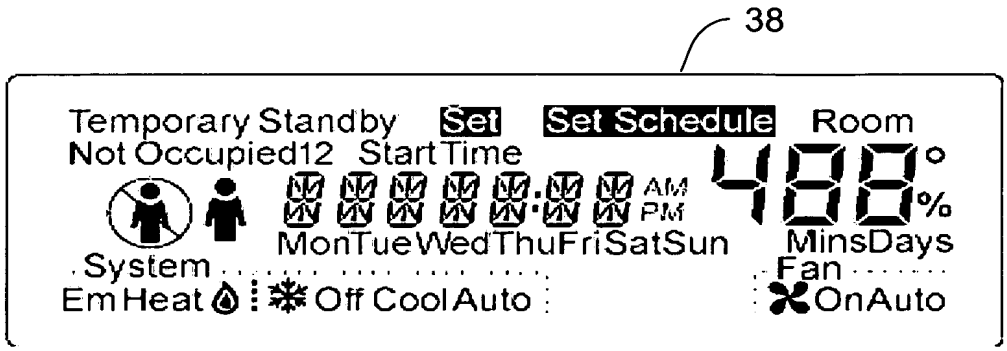

Figure 20A

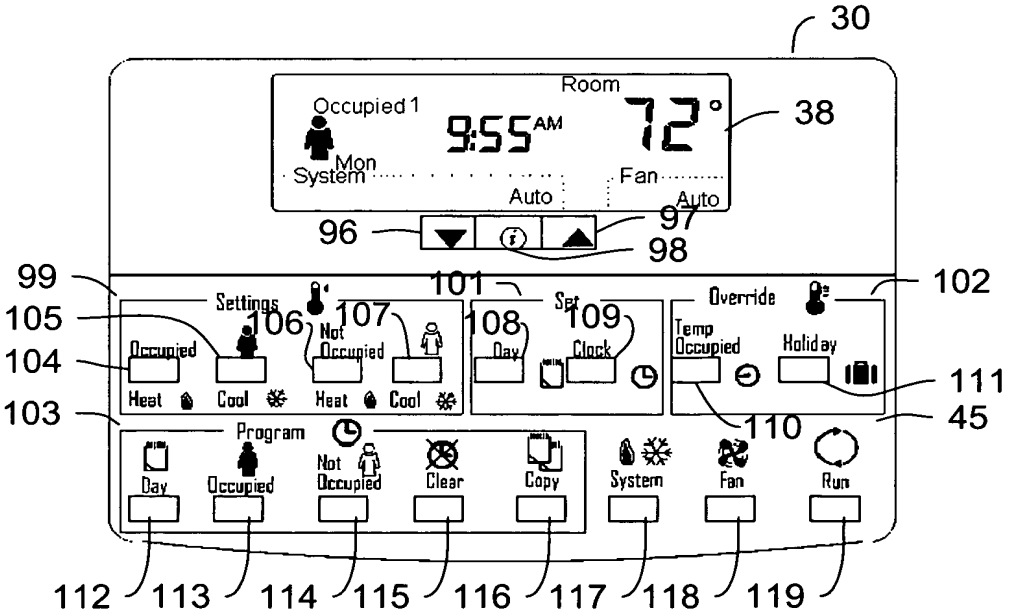

Figure 20B

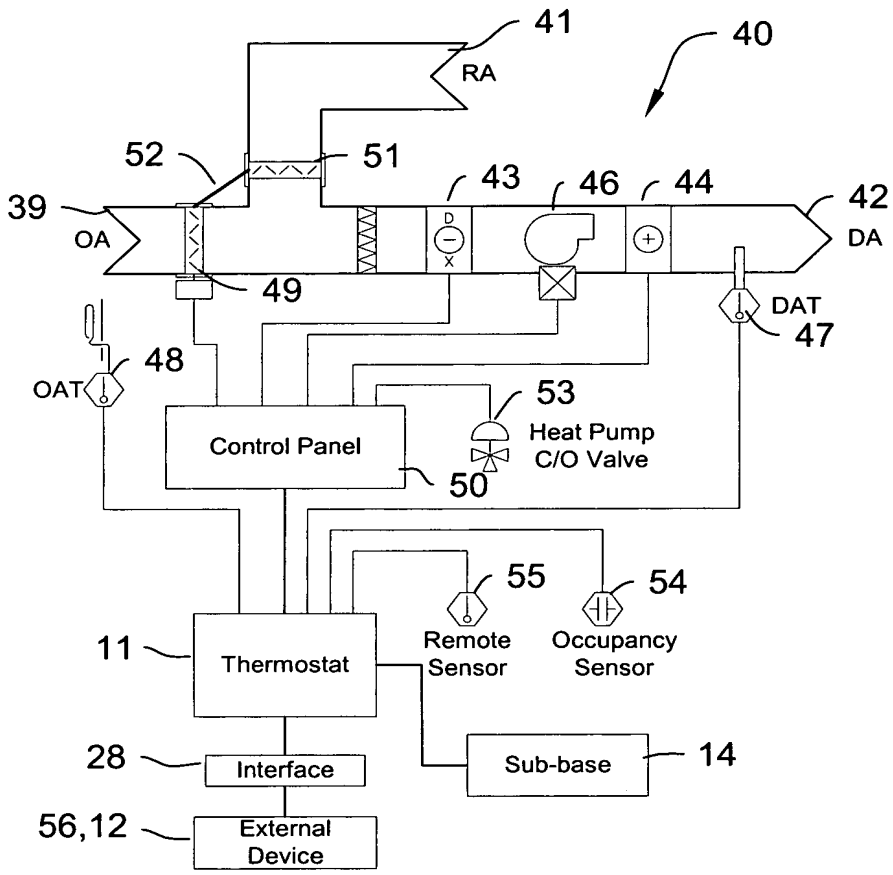
41
RA
40
52
51
43
46
44
42
39
OA
DA
49
DAT
47
48
OAT
53
Heat Pump
C/O Valve
Control Panel
50
55
54
11
Thermostat
Remote
Sensor
Occupancy
Sensor
28
Interface
Sub-base
14
56,12
External
Device

Figure 21

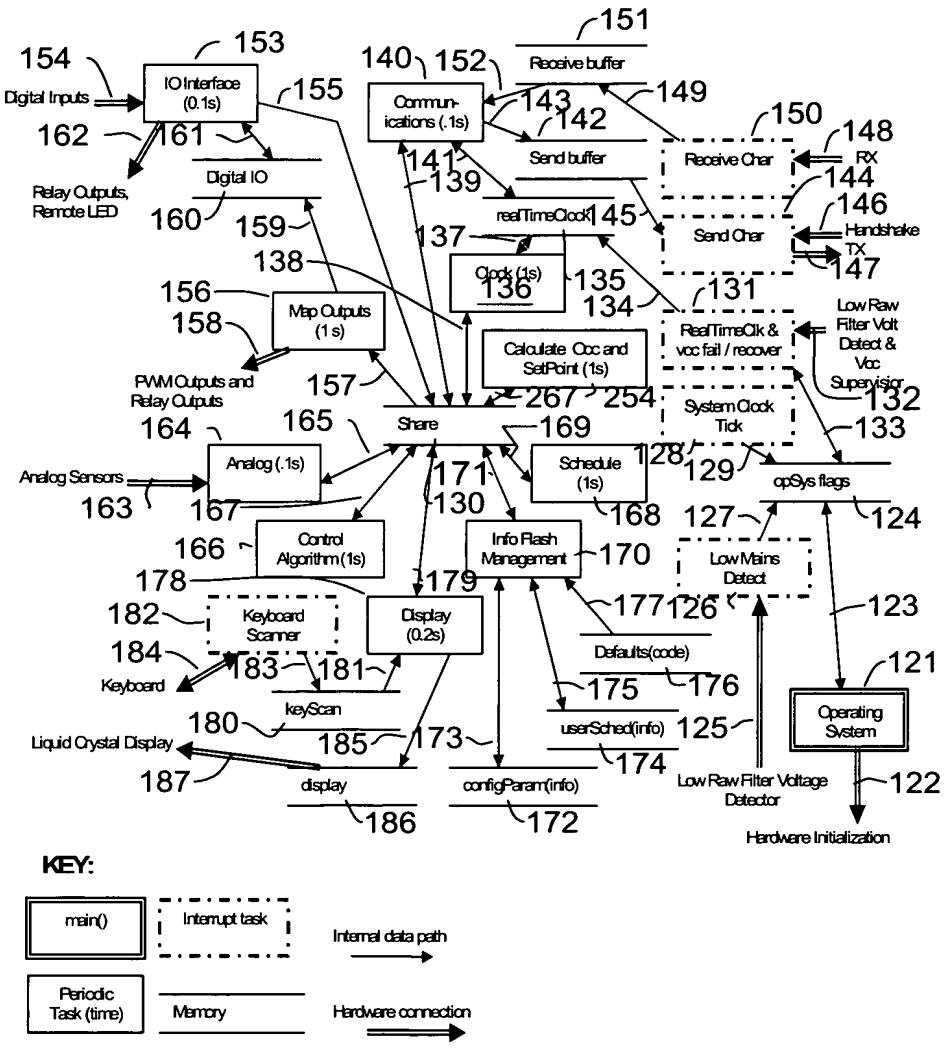
IO Interface (0.1s)
Digital Inputs
Relay Outputs, Remote LED
Digital IO
Map Outputs (1 s)
PWM Outputs and Relay Outputs
Analog (.1s)
Analog Sensors
Control Algorithm (1s)
Keyboard Scanner
Keyboard
Liquid Crystal Display
keyScan
display
Communications (.1s)
Receive buffer
Send buffer
realTimeClock
Clock (1s)
Calculate Occ and SetPoint (1s)
Share
Schedule (1s)
Info Flash Management
Display (0.2s)
configParam(info)
userSched(info)
Defaults(code)
Receive Char
Send Char
RealTimeClk & vcc fail / recover
System Clock Tick
Low Mains Detect
Low Raw Filter Voltage Detector
opSys flags
Operating System
Hardware Initialization
RX
Handshake
TX
Low Raw Filter Volt Detect & Vcc Supervisor
KEY:
main()
Interrupt task
Internal data path
Periodic Task (time)
Memory
Hardware connection

Figure 22

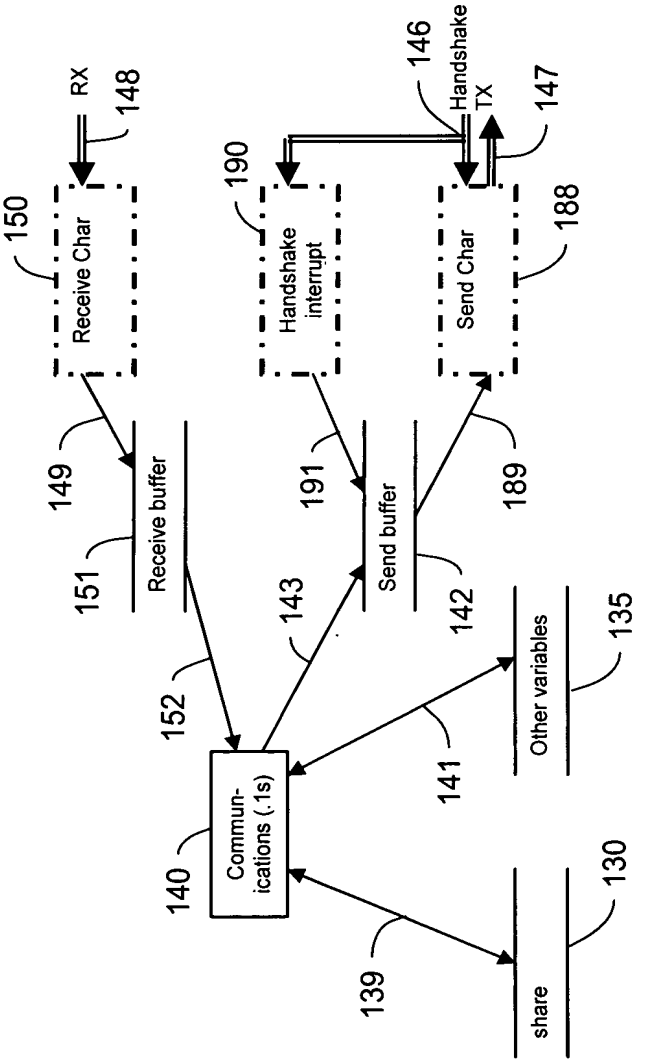
RX
148
146
Handshake
TX
147
150
Receive Char
190
Handshake
interrupt
188
Send Char
149
191
189
151
Receive buffer
Send buffer
143
142
152
Other variables
135
141
140
Commun-
ications (.1s)
139
share
130

Figure 23

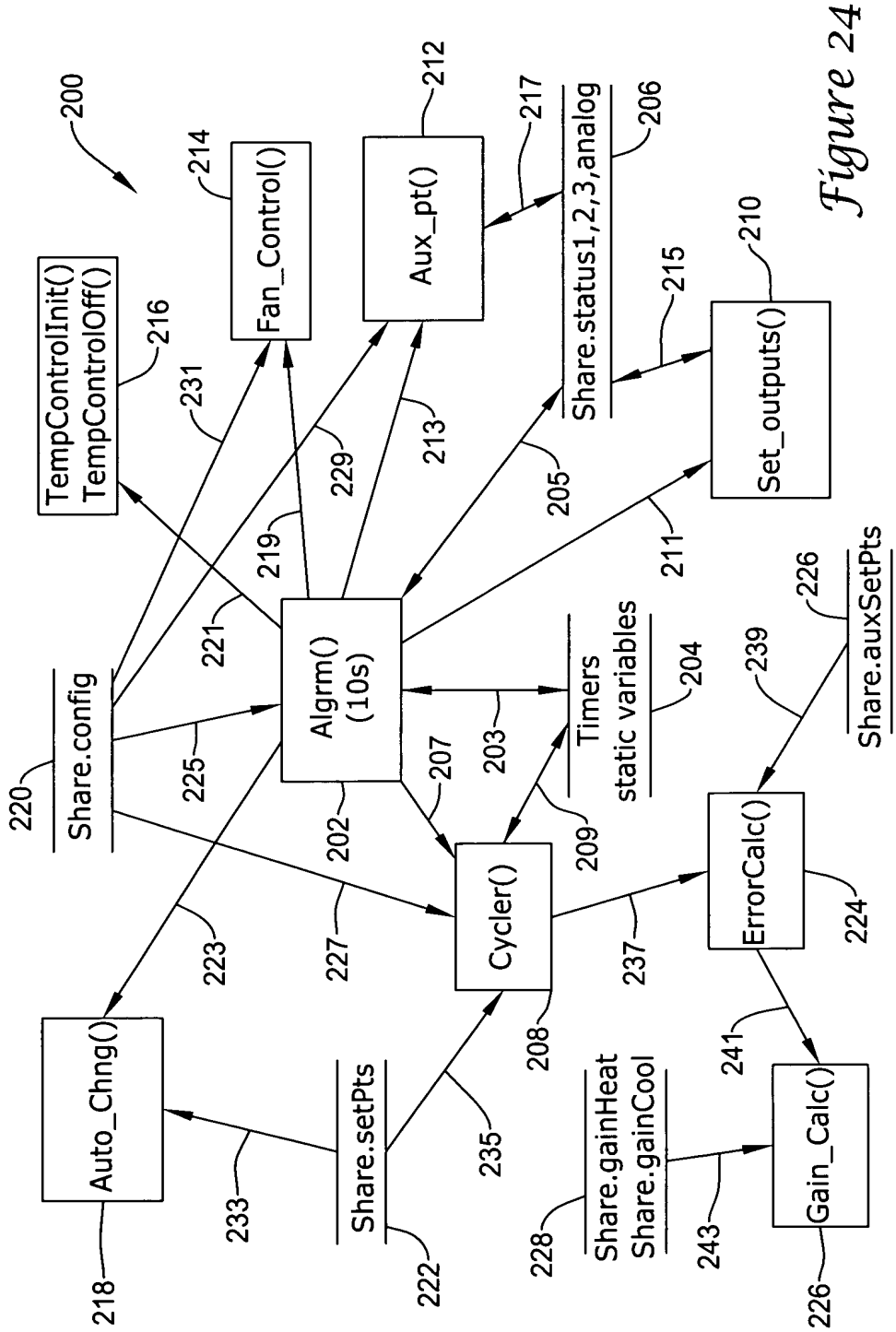
200
TempControlInit()
TempControlOff()
216
Fan_Control()
214
Aux_pt()
212
Share.status1,2,3,analog
206
Set_outputs()
210
Share.config
220
Algrm()
(10s)
Timers
static variables
204
Share.auxSetPts
226
Auto_Chng()
218
Share.setPts
222
Cycler()
208
ErrorCalc()
224
Share.gainHeat
Share.gainCool
228
Gain_Calc()
226
231
229
213
217
205
215
211
219
221
225
223
227
202
207
203
209
239
237
241
233
235
243

Figure 24

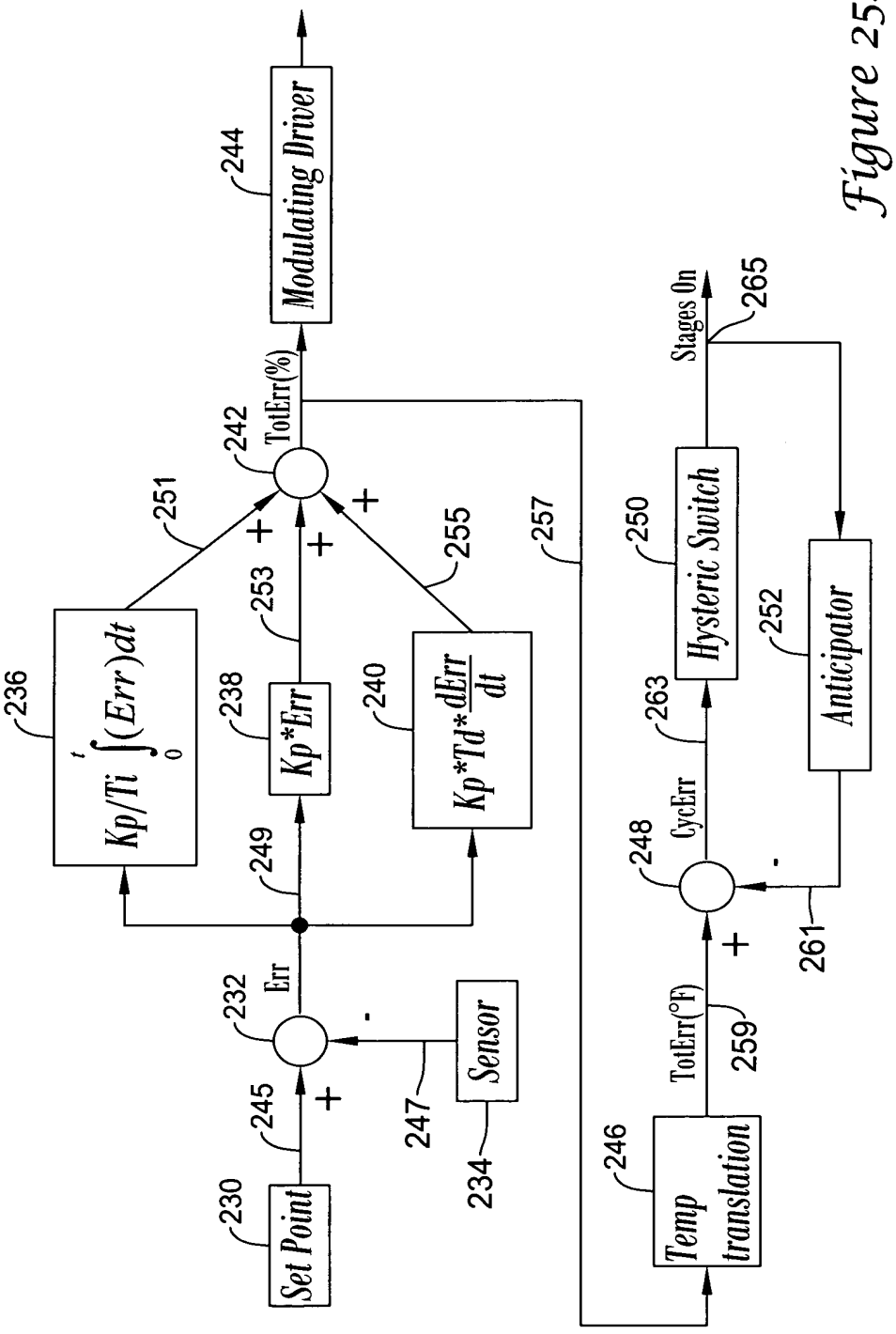
Modulating Driver
244
TotErr(%)
242
Kp/Ti $\int_0^t (Err)dt$
236
Kp*Err
238
Kp*Td*$\frac{dErr}{dt}$
240
251
253
255
257
Err
232
Set Point
230
Sensor
234
245
247
249
Hysteric Switch
250
Anticipator
252
Stages On
265
CycErr
263
TotErr(°F)
259
Temp translation
246
248
261

Figure 25A

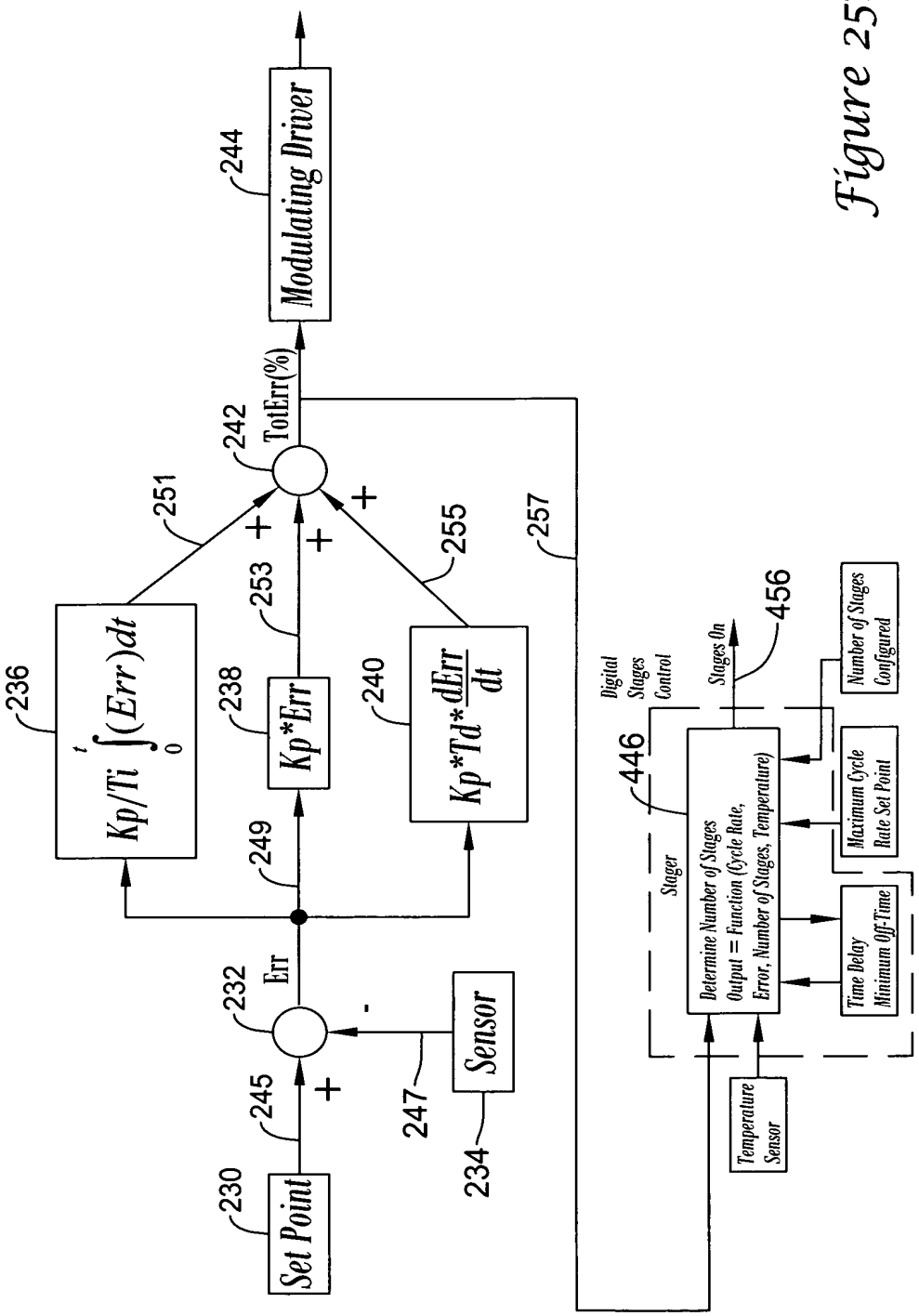
Modulating Driver
244
TotErr(%)
242
251
253
255
257
Kp/Ti $\int_0^t (Err)dt$
236
Kp*Err
238
Kp*Td*$\frac{dErr}{dt}$
240
249
Err
232
245
Set Point
230
247
Sensor
234
Digital Stages Control
Stager
446
Determine Number of Stages Output = Function (Cycle Rate, Error, Number of Stages, Temperature)
Stages On
456
Time Delay Minimum Off-Time
Maximum Cycle Rate Set Point
Number of Stages Configured
Temperature Sensor

Figure 25B

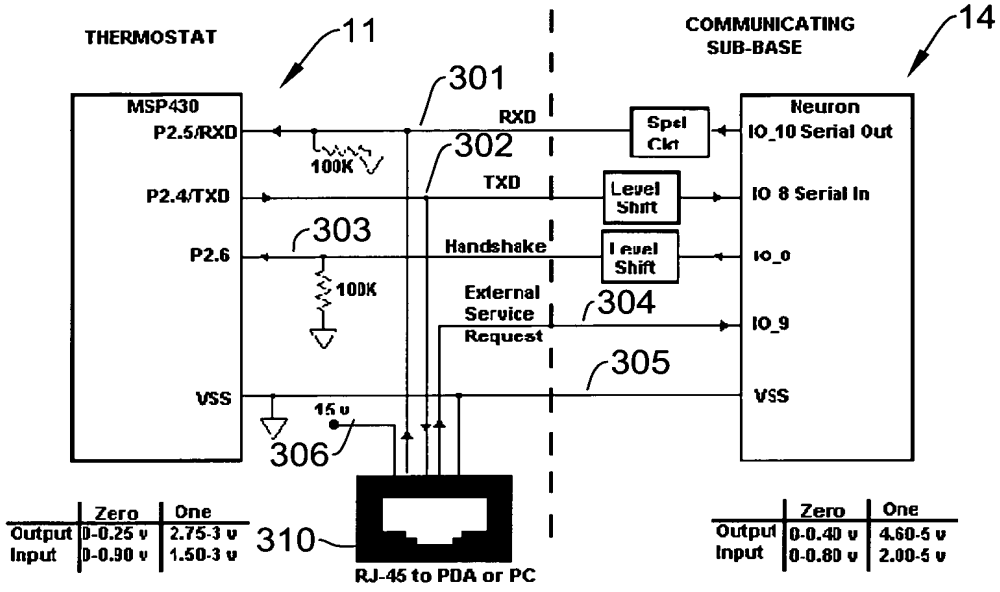

Figure 26

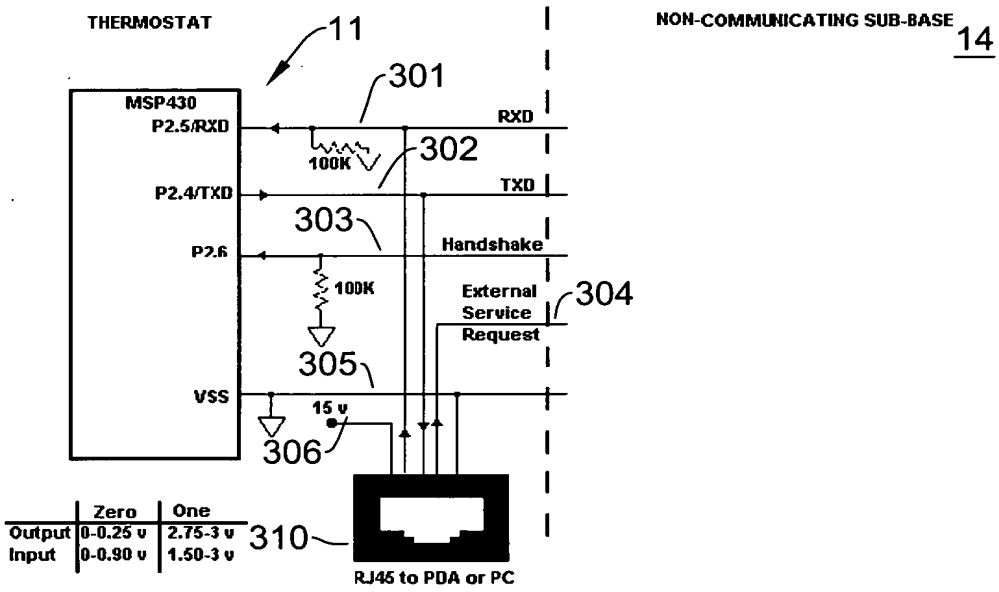

Figure 27

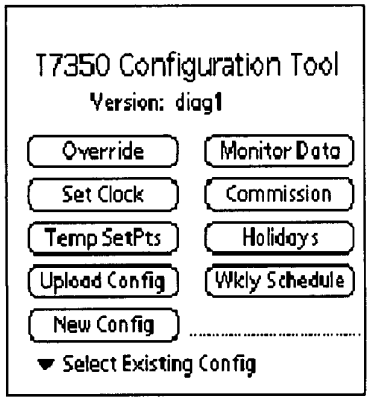

Figure 28A

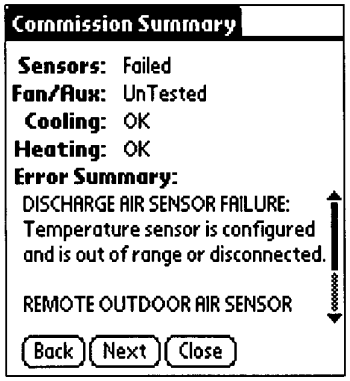

Figure 28C

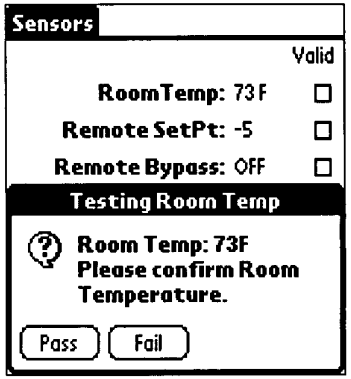

Figure 29B

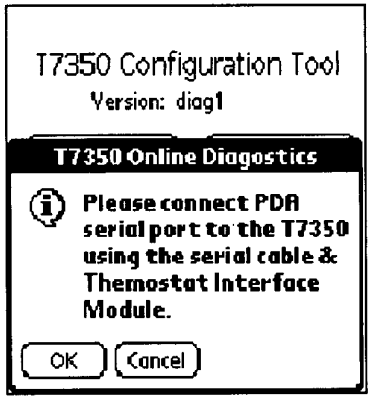

Figure 28B

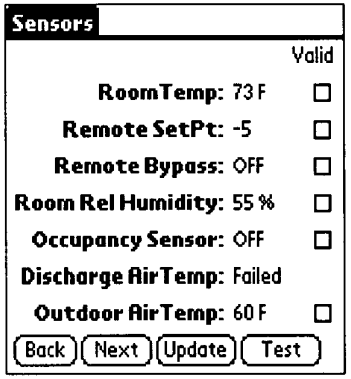

Figure 29A

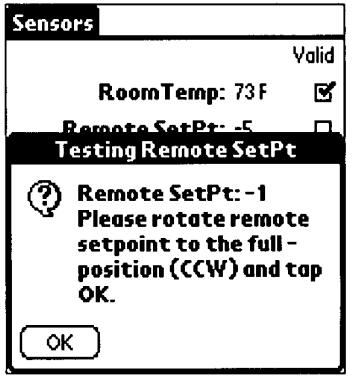

Figure 29C

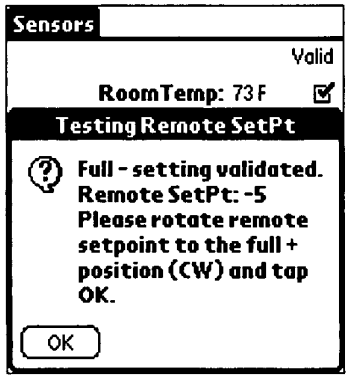

Figure 29D

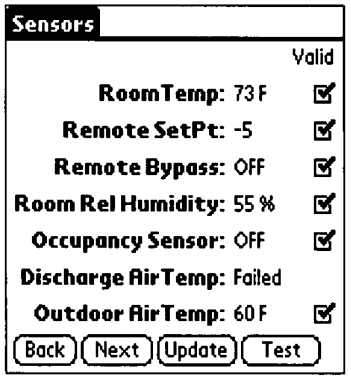

Figure 29F

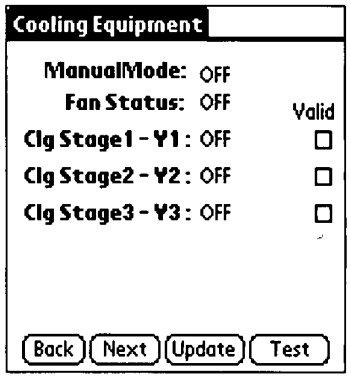

Figure 31A

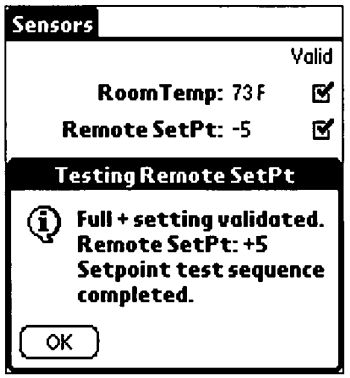

Figure 29E

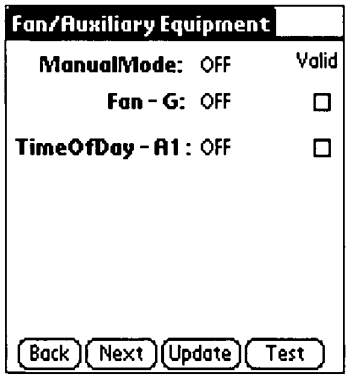

Figure 30

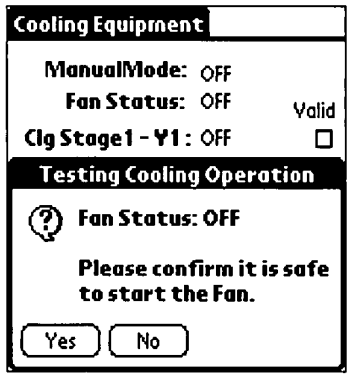

Figure 31B

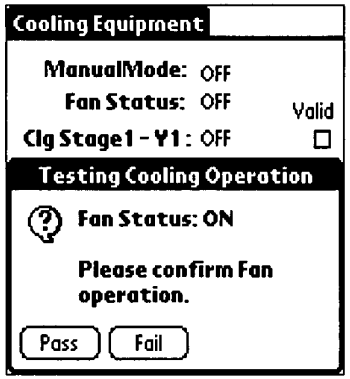

Figure 31C

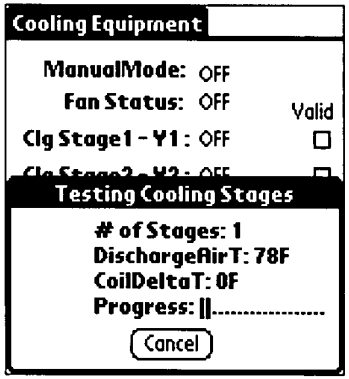

Figure 31E

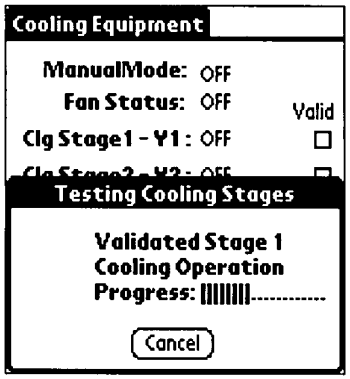

Figure 31G

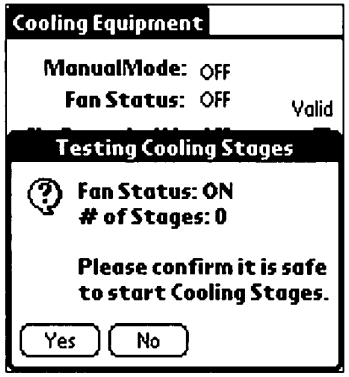

Figure 31D

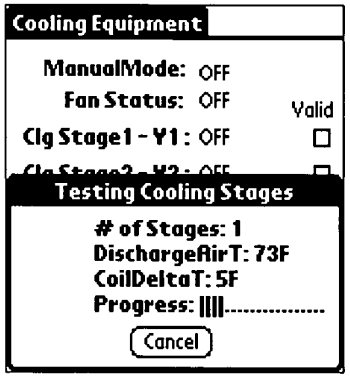

Figure 31F

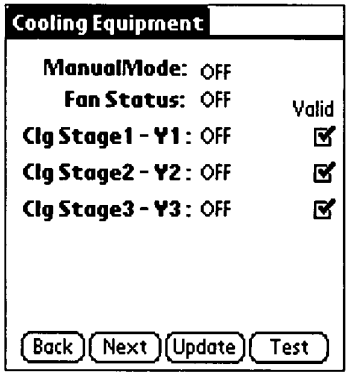

Figure 31H

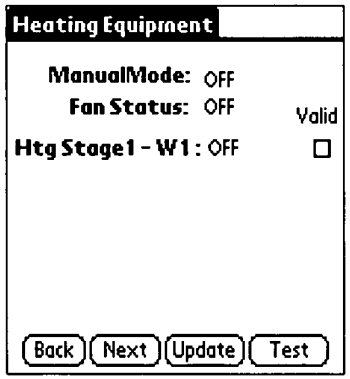

Figure 32A

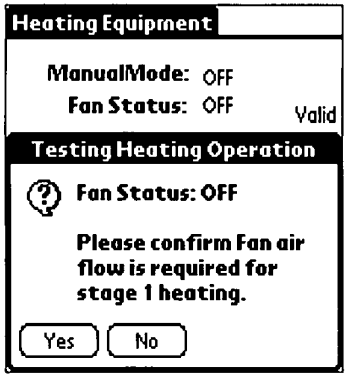

Figure 32B

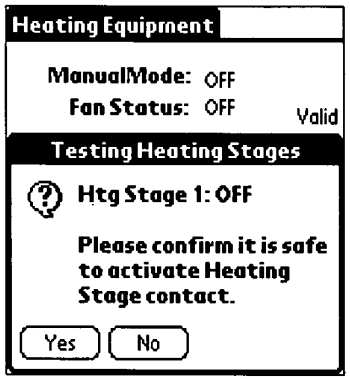

Figure 32C

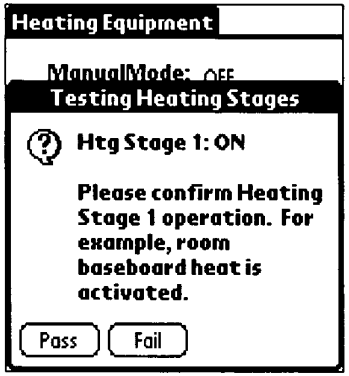

Figure 32D

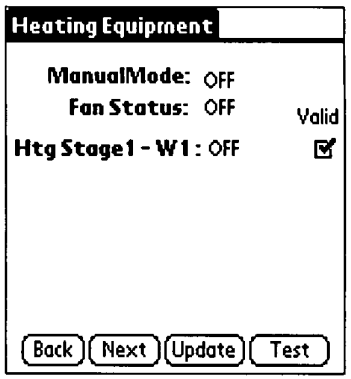

Figure 32E

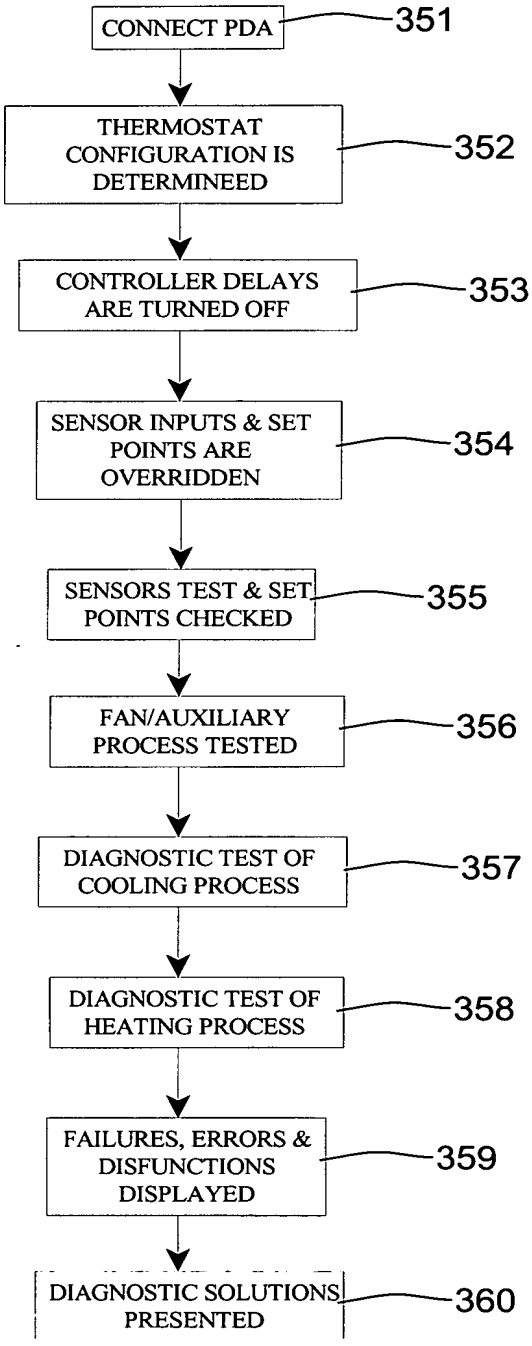
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Figure 33